

Controlling the significance of BLDC motor internal faults using dual examine algorithm in electric vehicle applications

Gaurav¹, Jayaram Nakka¹, Dakka Obulesu², Sairaj Arandhakar¹

¹Department of Electrical Engineering, National Institute of Technology Andhra Pradesh, Tadepalligudem, India

²Department of Electrical Engineering, CVR College of Engineering, Hyderabad, India

Article Info

Article history:

Received Mar 6, 2023

Revised May 10, 2023

Accepted May 25, 2023

Keywords:

Aspiration criteria

Dual examine algorithm

Electric vehicle

Genetic algorithm

Phase current distortion

Residual error

ABSTRACT

This paper presents dual examine algorithm (DEA) to reduce residual error as well as to provide accurate phase currents without any distortion for a closed loop brushless direct current (BLDC) motor of an electric vehicle (EV). The underlying technology of DEA is a hybrid of the tabu search optimization (TSO) method and the genetic algorithm (GA). During closed loop operation of BLDC motor residual error is introduced by the discrepancy between the actual and reference speed, and the phase current distortion lowers the efficiency of the machine as a result machine performance is degraded. To address these issues, GA algorithm calculates the necessary parameters for the controller to produce precise current without distortion based on stator phase currents, and the suggested TSO algorithm limits the repeated operations in the PID controller to reduce the residual error to the greatest degree feasible. After primary examining, dual examine process initiate the transposing operation such as TSO is used to prove and calculate the phase current controller parameters, and GA is used to correct for remaining inaccuracy. To validate the proposed DEA algorithm is compared with advanced particle swarm optimization (APSO). The results verified the superiority of proposed DEA algorithm using MATLAB/Simulink platform.

This is an open access article under the [CC BY-SA](#) license.



Corresponding Author:

Sairaj Arandhakar

Department of Electrical Engineering, National Institute of Technology Andhra Pradesh

Tadepalligudem-534101, India

Email: pf052202@student.nitandhra.ac.in

1. INTRODUCTION

The brushless DC (BLDC) motors are universally adopted in many applications due to their compact structure, robust operation, and easy maintenance [1], [2]. Based on the application and requirement, BLDC motors need to vary the speed, hence speed control is essential. Input voltage and current are the two parameters fed to the PID controller to regulate the speed of the BLDC motor [3]. In literature, different conventional and intelligent techniques are proposed to regulate the speed of the BLDC motor in a smooth way [4], [5]. Lee *et al.* [6], proposed and effectively reduced the distortion current of 1- Φ BLDC motor by minimizing the torque ripples during high-speed operation. The proposed Reference Voltage Controlled PWM technique is affected by the undervalue of a reference voltage. Tang *et al.* [7], investigated and stated that the increase in axial magnetic force ripple is the root cause of vibration and acoustic noise in a single-phase, 4-pole, BLDC motor by developing a magnetic circuit.

An optimum model is defined, which has minimum magnetic ripple using the same magnetic circuit and finite element method (FEM) simulation. By the defined model the author has effectively eliminated the vibrations and noise from the motor. Arandhakar *et al.* [8] trained and implemented the convolution neural network (CNN) to optimize the parameters of the PID controller in controlling the speed of the BLDC motor.

Khan and Miah [9], proposed a control mechanism to pump fluids with different specific gravity using a BLDC motor. The features of the design are benchmarked as the pump can operate at higher efficiency and is completely independent of fluid type and specific gravity. But due to the integration of control mechanisms, the maintenance of the system is very high compared to the existing motors designed for the same purpose. Potnuru and Saibabu [10], implemented flower pollination algorithm (FPA) using dSpace board to control the speed of the BLDC motor. Integral square error is considered as the objective function for optimizing the algorithm in the tuning of PID controllers. The author has succeeded in varying and controlling the speed of the motor [11]–[14]. Krall *et al.* [15], performed a real-time experiment on the measurement of electromagnetic compatibility (EMC) on a fractional horsepower drive in a closed chamber. With the help of the proposed angle modulated switching strategy the size of the filter is reduced from nine to four capacitors. In addition, the impact of airborne and structure-borne noise is examined.

Kumar and Singh [16], implemented a bidirectional power flow control strategy for a solar-powered BLDC motor. With the incorporation of an effective power tracking scheme and minimizing the switching losses [17]–[20]. The author has succeeded in extracting the maximum solar power to provide constant power to the water pumping. The layout of BLDC motor with electrical components is shown in Figure 1. The proposed DEA algorithm eliminates BLDC motor internal defects due to its transposed nature. TSO method addresses stator defects and GA detects residual speed error. Transposed operation is added to the system after assessment to make the BLDC motor work properly. The rest of the paper is organized as follows: i) After presenting the introduction and mathematical equations governing the modeling of BLDC motors in section 2; ii) Section 3 illustrates in detail the implementation and transpose working of the proposed dual examine algorithm (DEA); iii) The result in analysis and performance of the proposed algorithm in comparison with the existing PSO algorithm is presented in section 4; and iv) The summary of the given work is presented in section 5.

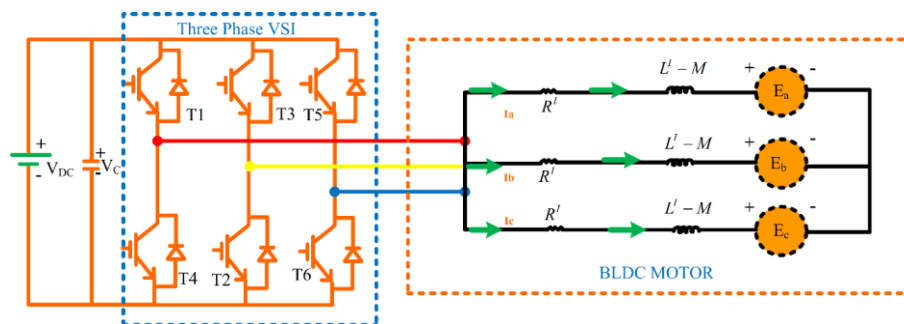


Figure 1. Layout of the BLDC motor for high-speed operation

2. MATHEMATICAL MODELLING

Torque control analysis and speed control analysis are shown in the mathematical modelling of the BLDC motor. According to this analysis, the minor signals produced by the electromechanical system have an average value model of PMSM. This model may be obtained by using the non-sinusoidal back EMF in the same way as BLDC utilizes the trapezoidal back EMF [21]–[23]. The electrical parameters of BLDC motor are shown in Table 1.

Table 1. Electrical specifications of the BLDC motor

S. No	Parameter	Numerical value
1	Phase resistance (R^l)	0.7Ω
2	Phase Inductance (L^l)	27.2 mH
3	Graded speed	3000 rpm
4	Rotor Inertia (J^l)	2×10^{-4} kg-m ²
5	Rotor Flux (φ)	0.2158 wb
6	Friction coefficient (f_r)	0.2
7	Corresponding poles	4
8	Rated power	1200 W

BLDC motors feature three windings on its permanent magnet stator and rotor. No damper windings are needed if the magnet and stainless-steel retaining sleeves have high resistance [24]–[26].

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = R^I \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} + \begin{bmatrix} L^I - M & 0 & 0 \\ 0 & L^I - M & 0 \\ 0 & 0 & L^I - M \end{bmatrix} \frac{d}{dt} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix} + \begin{bmatrix} E_a \\ E_b \\ E_c \end{bmatrix} \quad (1)$$

Here R^I is Resistance of phase, m is Mutual Inductance, L^I is Inductance of phase. The torque (T_e), speed (ω_r) equation obtained using inertia (J^I) and frictional force (f_r) as (2).

$$J^I \cdot \frac{d\omega_r}{dt} = T_e - T_l - f_r \omega_r \quad (2)$$

3. PROPOSED DEA TECHNIQUE

The proposed dual examine algorithm (DEA) is a combination of tabu search optimization (TSO) and genetic algorithm (GA). The maximum percentage of speed error is eliminated by proper tuning of the PID controller, but still there exists some amount of error and technically this error is named as a residual error. Due to the presence of residual error stator phase winding currents are distorted, resulting in the malfunctioning of the motor i.e., the speed control will be in an undesired manner. It is worthwhile to benchmark the two problems during high-speed operation as the existence of i) residual error and ii) distortion of phase currents. Therefore, in this paper two algorithms are employed to eliminate the above-advanced problem. Initially, TSO is trained to eliminate or minimize the content of residual error to the possible extent. Similarly, the distorted phase currents will be governed by GA. The percentage change in stator phase currents during the operation is called distortion phase current and the formula for residual error (RE) is given in terms of actual speed (N_A) and reference speed (N_{Ref}) in rpm as:

$$RE = \left[\frac{N_A - N_{Ref}}{N_{Ref}} \right] \quad (3)$$

3.1. Tabu search optimization

Tabu search metaheuristic algorithm has an effective searching strategy, especially for nonlinear equations. In this particular scenario, the TSO is used to obtain essential and desired parameters to reduce the content of residual error in the system. During computation, the strategic moves escape from the local minima as shown in Figure 2. TSO allows for avoiding problems associated with reaching local optimums by selecting suboptimal solutions as depicted in Figure 2(a). This process will continue until an optimal solution has been found, at which point the reduced residual error in speed is sent to further assessment criteria. The repeated pattern as shown in Figure 2(b).

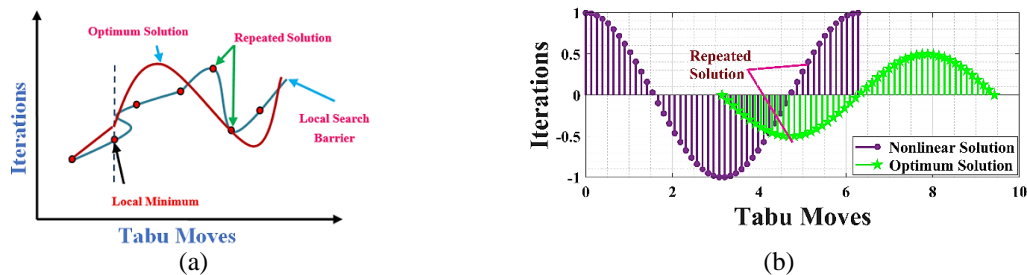


Figure 2. Flow pattern of (a) tabu movement strategy and (b) non-linear movement

The new tabu solution occurs after including the residual error parameter in tabu list and the new solution is represented as (3).

$$S = N^I(S) = \{N^I(S) - T^I(S)\} + A^I(S) \quad (3)$$

Where: S is the old solution, $N^I(S)$ is new solution, $T^I(S)$ is the updated Tabu list, and $A^I(S)$ is the aspiration criteria. The computation process of TSO depends on the size of tabu list. After every iteration, the list will be updated and compared with neighborhood speed error data. If the data obtained after computation exists in desired manner, then the solution and corresponding tabu moves are accepted and this particular desired solution is named as aspiration criteria and the convergence of the TSO strategy as depicted in Figure 3(a).

3.2. Genetic algorithm

Genetic algorithm has a futuristic approach, among the family of evolutionary algorithm. The purpose of GA is to generate high-quality situations for an optimization problem. Distorted phase current data is considered as the initial population, after iteration if the obtained solution satisfies the convergence value.

This particular solution is treated as the optimum solution. If not, the solution is reevaluated and the best value of individuals is separated, rest of the individuals are neglected. Now from the individual selection again computations are processed and the highest fitness value function is marked and the rest of the values are assumed values. The individually selected solution crossover with each other to generate a new solution. The solution is mated to each other in order to obtain the best value. The obtained best value is revived in the convergence section. Figure 3(b) depicts the flow chart of the genetic algorithm. The training validation of TSO and GA are depicted in Table 2 and Table 3 respectively.

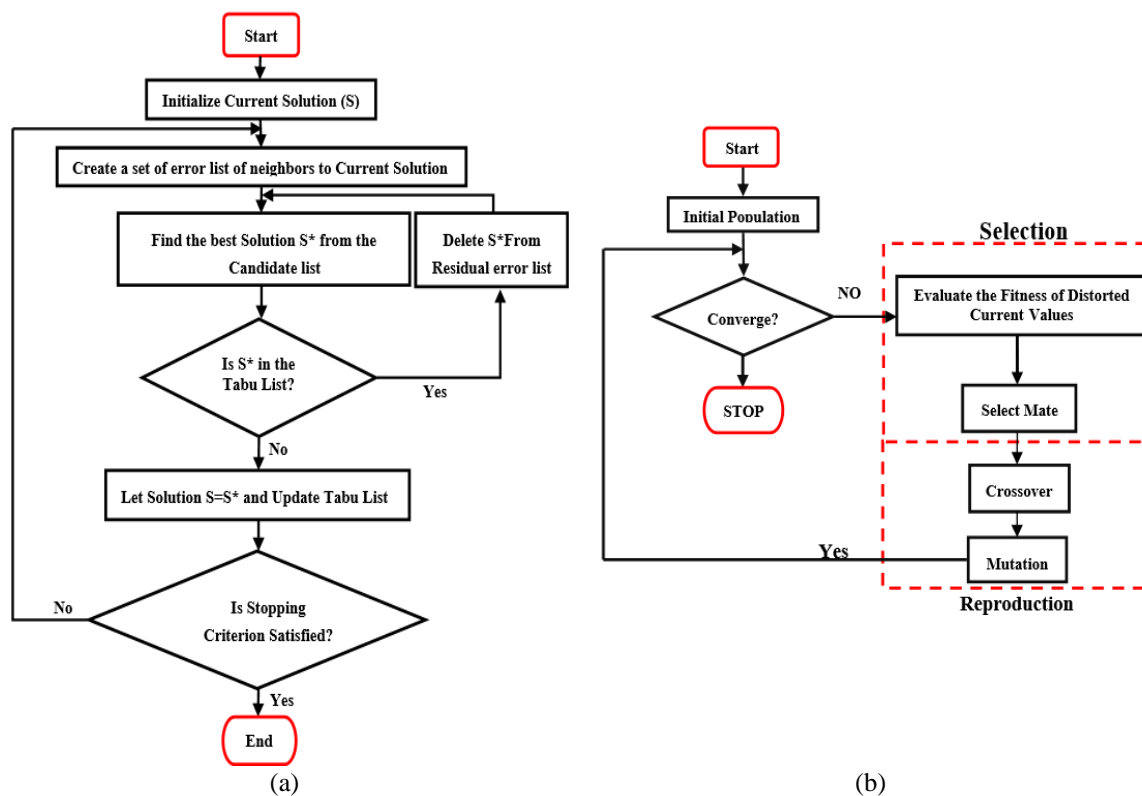


Figure 3. Flowchart of (a) tabu search optimization (TSO) algorithm and (b) genetic algorithm

Table 2. Parameters of TSO

Parameter	Value
Deviation from the mean as an acceptance criterion	1
Maximum Number of generations	100* number of variables
Total number of top-performing TL	TN/5
TL tabus	3* number of variables

Table 3. Training data of GA parameters

Parameter	Value
Crossover	Arithmetic crossover
EliteCount	3
Population size	50
Number of generations	100
Crossover probability	0.88
Mutation probability	0.2
Mutation	Uniform

3.3. Transpose working of DEA

Initially, TSO and GA are simulated individually to address as well as minimize the effect of residual error and stator-distorted phase currents. After completing the computational/iteration process the PID controller is tuned as per the best values attained by TSO and GA. Thereafter the transpose nature of the algorithms is activated i.e., the best values obtained by TSO to eliminate the residual error are revived and if necessary returned by GA. Similarly, the values obtained by GA are verified by TSO, such that the existence of residual error, as well as distorted phase currents, are minimized to the possible extent. Figure 4 represents the block diagram of DEA in tuning the PID control of the closed-loop BLDC motor of EV prototype. The PID tuning parameters are K_P , K_I , K_D which are responsible to vary the internal faults data and also acts as input command signals/data to the proposed DEA algorithm. The condition for transpose working $\delta < 0.07$ for residual error and for distorted phase currents $\varepsilon < 0.3$ as shown in Figure 5 and after transposition the system accuracy increases.

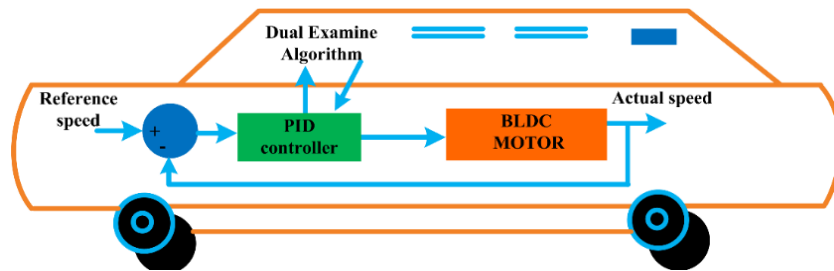


Figure 4. Tuning of PID controller with dual examine algorithm in EV

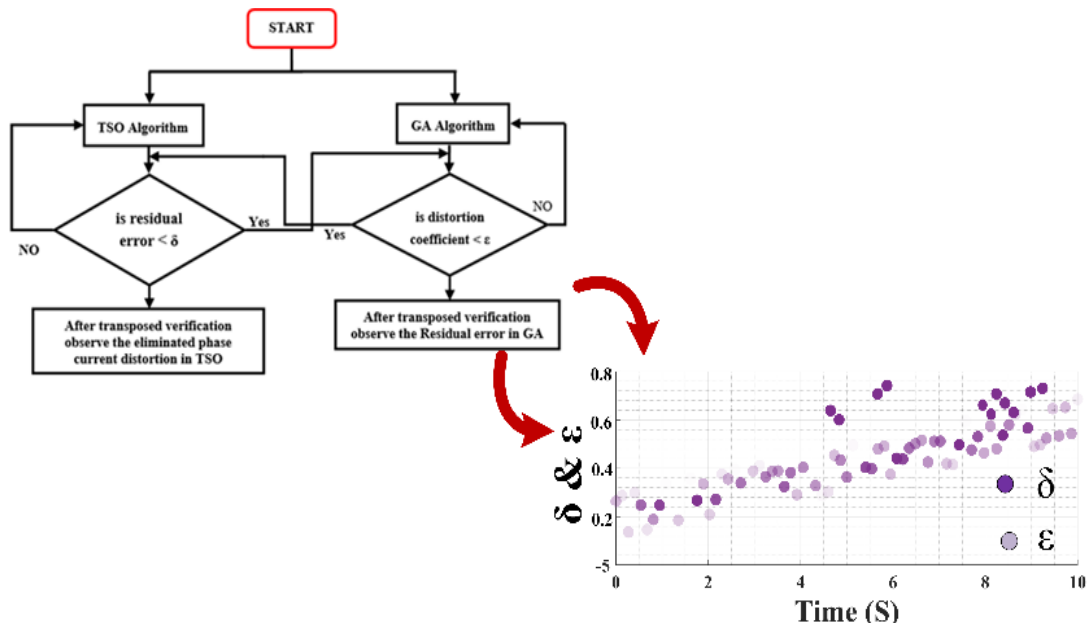


Figure 5. Flowchart of dual examine algorithm

4. SIMULATION RESULTS

Using MATLAB/Simulink a common model is developed for both the existing PSO and the proposed DEA algorithm. At no load condition, the reference speed of the motor is 900 rpm as shown in Figure 6. The red dotted line in the figure represents various levels of reference speed i.e., 800 rpm, 750 rpm and 600 rpm. Similarly, the black line indicates the actual speed of the motor using APSO algorithm and the green line represents actual speed using the proposed DEA algorithm shown in Figure 6(a).

The numerical value of the residual error for different speed levels is depicted in Table 4. As compared to the APSO method that is currently in use, the DEA algorithm that has been presented has been shown to be far more effective at reducing the amount of residual error that is produced which can be seen plainly from the table. The error values at various speeds for APSO and proposed DEA algorithm is depicted in Figure 6(b).

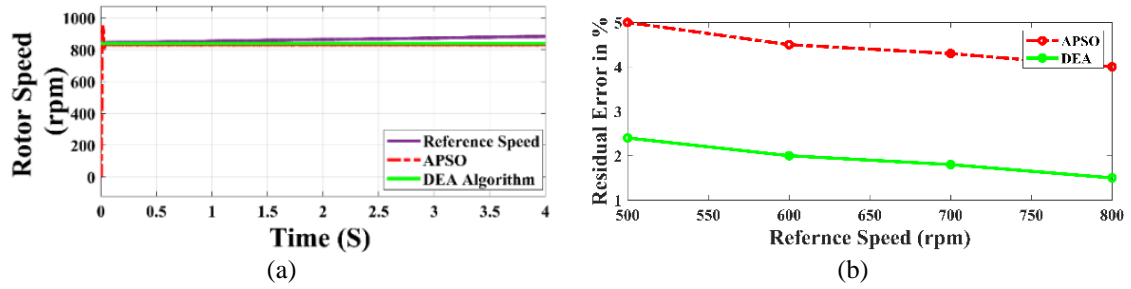


Figure 6. Simulation behaviour of (a) rotor speed of the BLDC motor representing the percentage of the residual error using both PSO and proposed DEA algorithm and (b) residual error behaviour at various speed levels for APSO and proposed DEA algorithm

Table 4. Residual error obtained by APSO and proposed DEA algorithms

S. No	Ref. Speed	Actual speed		Residual error (%)	
		APSO	DEA	APSO	DEA
1	800 rpm	765 rpm	780 rpm	4.5%	2.5%
2	750 rpm	720 rpm	735 rpm	4.3%	2.0%
3	600 rpm	575 rpm	590 rpm	4.3%	1.6%

4.1. Comparison of proposed DEA and APSO validation

Distortion in phase currents decreases the performance of BLDC motor. From Figure 7(a), it is observed that the phase currents (I_a , I_b , I_c) distortions are initiated at 84 A, and -57 A. More stator current fluctuations are occurred at 50 A to -50 A due to non-linearity introduced in the system. The corresponding deviation of current signals can be seen from 0 S to 0.04 S. In most cases, the iron loss effect results from a distorted stator current. In continuation, iron losses in the stator section cause electromagnetic torque error (ripple) in the BLDC motor. Figure 7(b) illustrates the progressive rise in pulsing torque that occurs at 0.5 S. Both the resulting back EMF is shown in Figure 7(c) and the terminal voltage of the BLDC motor are identified at the appropriate times from 0 S to 4 S, respectively. Validation through APSO is not achieving the anticipated outcomes since it is feasible to reach a local optimum in high-dimensional space and has a moderate convergence rate during the iteration process.

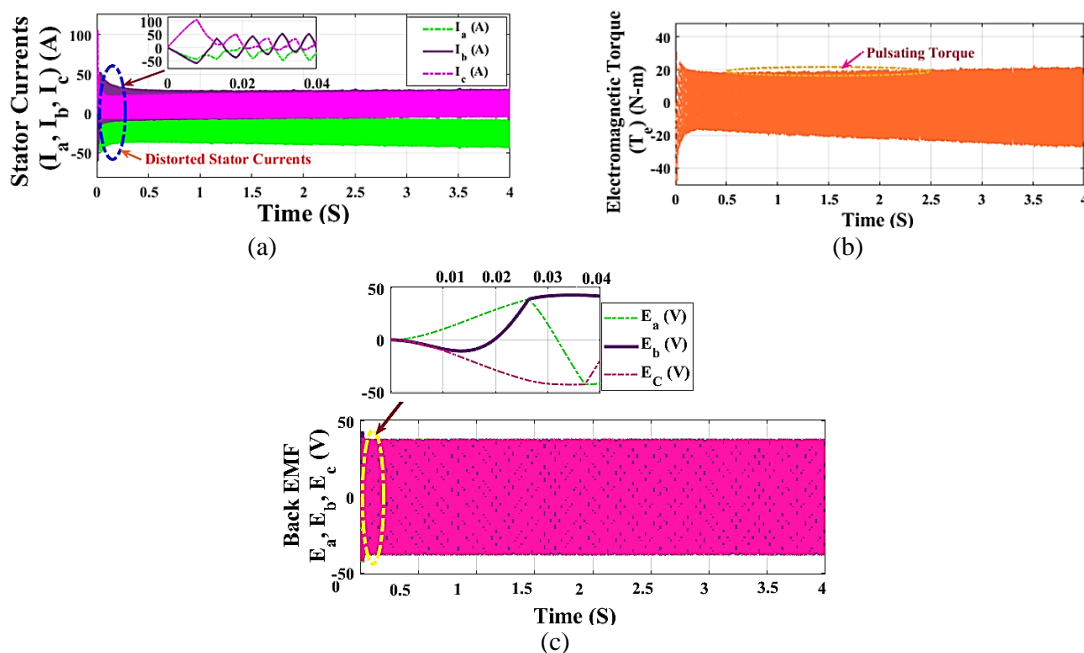


Figure 7. Simulation results: (a) stator phase currents (I_a , I_b , I_c) in A, (b) electromagnetic torque (T_e) in N-m, and (c) back EMF (E_a , E_b , E_c) in (V) of BLDC motor using APSO

Maintaining a constant uniform trapezoidal rotor flux to the closed loop BLDC motor is a major accomplishment for the proposed DEA algorithm. Starting at 0 S, the stator currents are distorted in DEA from 6.5 A to -6.5 A. Distortions in stator currents are minimized as seen in Figure 8(a) because of the availability of many optimum solutions reached using proposed DEA method. Torque ripples in BLDC motors are caused by the dynamic nature of the speed control. The suggested approach, shown in Figure 8(b), preserves the torque proportional to the load and the electromagnetic torque constant as the speed rises to the greatest extent feasible. As the rotational speed of the motor rises, so does the magnitude of the trapezoidal back-EMF as depicted in Figure 8(c). During speed control operations, it is responsible for maintaining constant torque.

The figure demonstrates that the amount of residual error is quite high when the PSO algorithm is used, in contrast to the situation in which the proposed DEA technique is utilized, in which the amount of residual error is very low. By evaluating the results of two programs with comparable net present value, the crossover rate is a relevant measure to utilize. The crossover rate of 0 to 1 is used for achieving the convergence of APSO and proposed DEA. As can be seen in Figure 9, the residual error is significantly reduced when compared to the APSO method.

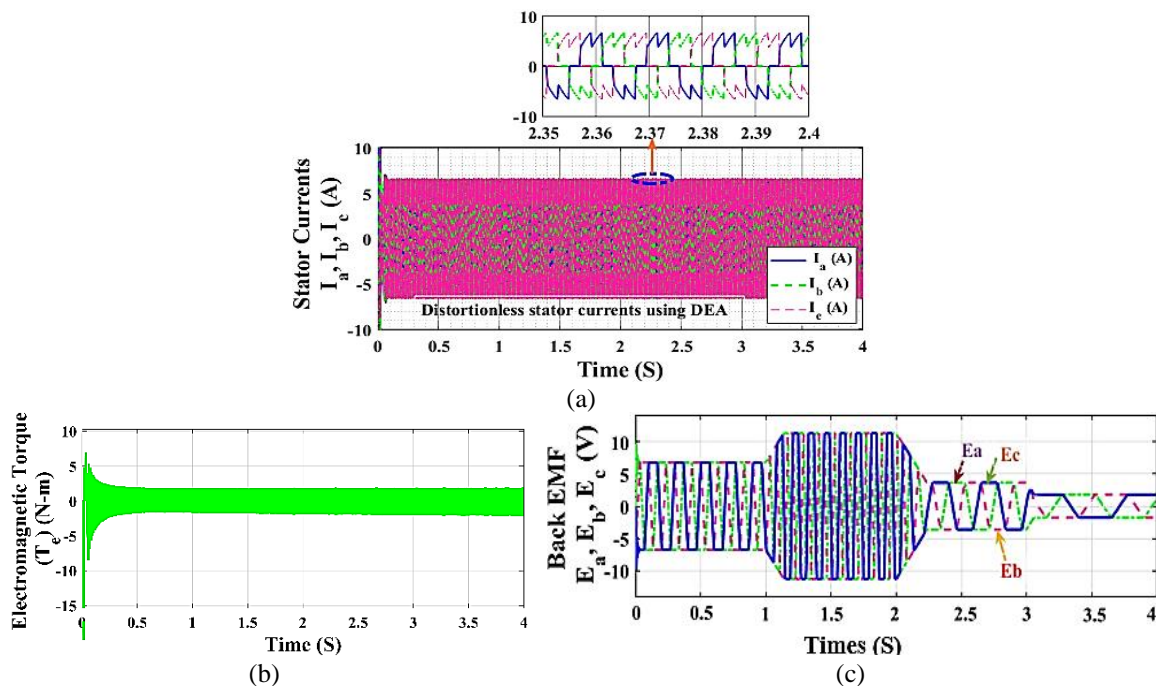


Figure 8. Simulation results: (a) stator phase currents (I_a , I_b , I_c) in A, (b) electromagnetic torque (T_e) in N-m, and (c) Back EMF (E_a , E_b , E_c) in (V) of BLDC motor using APSO

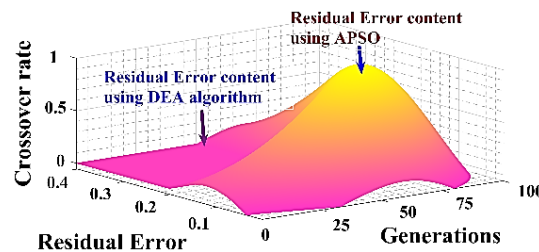


Figure 9. Residual Error comparison between APSO and proposed DEA algorithm for 100 iterations

5. CONCLUSION

The performance of the closed loop BLDC motor is affected by the content of residual error as well as stator phase current distortion. Therefore, this paper presents dual examine algorithm (DEA) to address the above problems. DEA is a combination of tabu search optimization (TSO) and genetic algorithm (GA). TSO




is initiated to tune the PID controller to reduce the content of residual error in the system by measuring the values of K_P , K_I , and K_D . Similarly, GA is computed to get the best-fit values that can compensate for the distortion phase currents. After attaining suitable values, a transpose working of the algorithm is started i.e., cross verification as well as retuning of the PID controller on demand. Due to the transposed working maximum content of the residual error and phase, distortion is eliminated. In this connection it is benchmarked that the simulation results attained from proposed algorithm has better performance when a closed-loop BLDC motor is operated under dynamic conditions.

REFERENCES




- [1] R. Y. Yamashita, F. L. Silva, F. M. Santiciolli, J. J. Eckert, F. G. Dedini, and L. C. A. Silva, "Comparison between two models of BLDC motor, simulation and data acquisition," *Journal of the Brazilian Society of Mechanical Sciences and Engineering*, vol. 40, no. 2, 2018, doi: 10.1007/s40430-018-1020-0.
- [2] M. A. Mohammed Eltoum, A. Hussein, and M. A. Abido, "Hybrid Fuzzy Fractional-Order PID-Based Speed Control for Brushless DC Motor," *Arabian Journal for Science and Engineering*, vol. 46, no. 10, pp. 9423–9435, 2021, doi: 10.1007/s13369-020-05262-3.
- [3] M. Baszynski and S. Pirog, "A novel speed measurement method for a high-speed BLDC motor based on the signals from the rotor position sensor," *IEEE Transactions on Industrial Informatics*, vol. 10, no. 1, pp. 84–91, 2014, doi: 10.1109/TII.2013.2243740.
- [4] A. Shabani, A. A. P. Tousiwas, M. Pourmandi, A. Khormali, and A. Ataei, "Optimization of brushless direct current motor design using an intelligent technique," *ISA Transactions*, vol. 57, pp. 311–321, 2015, doi: 10.1016/j.isatra.2015.03.005.
- [5] J. Gurram, N. S. Babu, and G. N. Srinivas, "Artificial neural network based DC-DC converter for grid connected transformerless PV system," *International Journal of Power Electronics and Drive Systems*, vol. 13, no. 2, pp. 1246–1254, 2022, doi: 10.11591/ijpeds.v13.i2.pp1246-1254.
- [6] W. Lee, D. Han, and B. Sarlioglu, "Comparative performance analysis of reference voltage-controlled pulse width modulation for high-speed single-phase brushless DC motor drive," *IEEE Transactions on Power Electronics*, vol. 33, no. 5, pp. 4560–4568, 2018, doi: 10.1109/TPEL.2017.2731962.
- [7] Z. H. Tang, Y. T. Chen, Y. K. Liou, and R. H. Liang, "Axial Magnetic Force Analysis and Optimized Design for Single-Phase BLDC Slim Fan Motors," *IEEE Transactions on Industrial Electronics*, vol. 68, no. 8, pp. 6840–6848, 2021, doi: 10.1109/TIE.2020.3007111.
- [8] S. Arandhakar, A. Kant, and M. N. Bhukya, "Implementation of Convolutional Neural Network for Speed Control of BLDC Motor," *Proceedings - 2021 International Conference on Design Innovations for 3Cs Compute Communicate Control, ICDI3C 2021*, pp. 35–40, 2021, doi: 10.1109/ICDI3C53598.2021.00016.
- [9] K. R. Khan and M. S. Miah, "Fault-Tolerant BLDC Motor-Driven Pump for Fluids with Unknown Specific Gravity: An Experimental Approach," *IEEE Access*, vol. 8, pp. 30160–30173, 2020, doi: 10.1109/ACCESS.2020.2972942.
- [10] D. Potnuru, A. M. K., and C. Saibabu, "Design and implementation methodology for rapid control prototyping of closed loop speed control for BLDC motor," *Journal of Electrical Systems and Information Technology*, vol. 5, no. 1, pp. 99–111, May 2018, doi: 10.1016/j.jesit.2016.12.005.
- [11] K. Vanchinathan and N. Selvagesan, "Adaptive fractional order PID controller tuning for brushless DC motor using Artificial Bee Colony algorithm," *Results in Control and Optimization*, vol. 4, 2021, doi: 10.1016/j.rico.2021.100032.
- [12] B. V. and Y. Mohamed Shuaib, "Minimization of torque ripples with optimized controller based four quadrant operation & control of BLDC motor," *Advances in Engineering Software*, vol. 172, no. August, 2022, doi: 10.1016/j.advengsoft.2022.103192.
- [13] R. Baz, K. El Majdoub, F. Giri, and A. Taouni, "Self-tuning fuzzy PID speed controller for quarter electric vehicle driven by In-wheel BLDC motor and Pacejka's tire model," *IFAC-PapersOnLine*, vol. 55, no. 12, pp. 598–603, 2022, doi: 10.1016/j.ifacol.2022.07.377.
- [14] T. Yigit and H. Celik, "Speed controlling of the PEM fuel cell powered BLDC motor with FOPI optimized by MSA," *International Journal of Hydrogen Energy*, vol. 45, no. 60, pp. 35097–35107, Dec. 2020, doi: 10.1016/j.ijhydene.2020.04.091.
- [15] F. Krall, H. Gruebler, and A. Muetze, "Analysis of the Angle Modulated Switching Strategy for use with Fractional Horse Power BLDC Motors," *IEEE Transactions on Power Electronics*, vol. 36, no. 5, pp. 5460–5472, 2021, doi: 10.1109/TPEL.2020.3028604.
- [16] R. Kumar and B. Singh, "Grid Interactive Solar PV-Based Water Pumping Using BLDC Motor Drive," *IEEE Transactions on Industry Applications*, vol. 55, no. 5, pp. 5153–5165, 2019, doi: 10.1109/TIA.2019.2928286.
- [17] R. Venkatesh, R. AnandhaKumar, and G. Renukadevi, "THD reduction in measurement of H - Bridge multilevel inverter using pulse modulated switching integrated with linear quadratic Regulator," *Measurement: Sensors*, vol. 24, p. 100435, Dec. 2022, doi: 10.1016/j.measen.2022.100435.
- [18] K. Vanchinathan, K. R. Valluvan, C. Gnanavel, C. Gokul, and J. R. Albert, "An improved incipient whale optimization algorithm based robust fault detection and diagnosis for sensorless brushless <sc>DC</sc> motor drive under external disturbances," *International Transactions on Electrical Energy Systems*, vol. 31, no. 12, pp. 1–23, Dec. 2021, doi: 10.1002/2050-7038.13251.
- [19] J. R. Albert, K. Ramasamy, V. Joseph Michael Jerard, R. Boddepalli, G. Singaram, and A. Loganathan, *A Symmetric Solar Photovoltaic Inverter to Improve Power Quality Using Digital Pulsewidth Modulation Approach*, no. 0123456789, 2023.
- [20] K. M. Sundaram, S. Padmanaban, J. B. Holm-Nielsen, and P. Pandiyan, *Photovoltaic Systems*. Boca Raton: CRC Press, 2022.
- [21] D. S. Nayak and R. Shivarudraswamy, "Loss and Efficiency Analysis of BLDC Motor and Universal Motor by Mathematical Modelling in the Mixer Grinder," *Journal of The Institution of Engineers (India): Series B*, vol. 103, no. 2, pp. 517–523, 2022, doi: 10.1007/s40031-021-00652-z.
- [22] Z. U. A. Zafar, N. Ali, and C. Tunç, "Mathematical modeling and analysis of fractional-order brushless DC motor," *Advances in Difference Equations*, vol. 2021, no. 1, 2021, doi: 10.1186/s13662-021-03587-3.
- [23] A. Rajesh and A. Gnana Saravanan, "Torque ripple minimization of bridgeless CUK converter-based BLDC motor using Improved Jellyfish Search Algorithm," *ISA Transactions*, no. xxxx, 2022, doi: 10.1016/j.isatra.2022.11.025.
- [24] A. Popenda, "Modelowanie silnika BLDC zasilanego przez różne układy przekształtnikowe," *Przegląd Elektrotechniczny*, vol. 94, no. 1, pp. 81–84, 2018, doi: 10.15199/48.2018.01.21.
- [25] A. Senthilnathan, P. Palanivel, and K. R. Kumar, "Mathematical Modelling and Torque Ripple Waning in BLDC Motor Using Outgoing-Phase Current Discharge Hysteresis Controlled ANFIS Controller," *Mathematical Problems in Engineering*, vol. 2022, 2022, doi: 10.1155/2022/3971695.
- [26] M. S. N. Krishna konijeti and M. L. Bharathi, "Extraction of maximum power from solar with BLDC motor driven electric vehicles based HHO algorithm," *Advances in Engineering Software*, vol. 170, no. April, 2022, doi: 10.1016/j.advengsoft.2022.103137.

BIOGRAPHIES OF AUTHORS






Gaurav    received B. Tech degree in Electrical Engineering from Dr. A.P.J. Abdul Kalam Technical University (AKTU), Greater Noida, India and M. Tech. in Electrical Power and energy system from National Institute of Technology, Srinagar (JK), India in 2018 and 2020 respectively. He is currently pursuing Ph.D. at National Institute of Technology Andhra Pradesh, India. His research interests include, high gain DC-DC converter, multilevel inverters, non-isolated bidirectional converters, power factor converters, grid integration of renewable energy systems, AC motor drives and control. He can be contacted at email: gaurav.sclr@nitandhra.ac.in.






Jayaram Nakka    received B. Tech degree in Electrical and Electronics Engineering from Jawaharlal Nehru Technological University, Hyderabad, India and M.Tech. from Vellore Institute of Technology, Vellore, India in 2007 and 2009 respectively. He received the Ph.D. degree in Electrical Engineering from Indian Institute of Technology, Roorkee, India in 2014. Currently he is with the Department of Electrical Engineering, National Institute of Technology Andhra Pradesh, India. He has published many international and national journals and conferences. He is the reviewer of many international journals. His research interests include multilevel inverters, high power converters, and renewable energy systems. He can be contacted at email: jayaram@nitandhra.ac.in.



Dakka Obulesu    received his B.E. degree in Electrical and Electronics Engineering from STJ Institute of Technology, Karnataka University, Karnataka, India, in 2000 and his M. Tech in Power Electronics and Drives from Dr. M.G.R. University in 2005. He received his Ph.D. degree in Electrical Engineering from JNTU, Hyderabad, India, in 2015. He has teaching experience of nearly 19 years. Currently, he is working as Associate Professor in CVR College of Engineering, Telangana, India, in the Department of Electrical & Electronics Engineering. He has published a number of research papers in various national and international journals and conferences. His areas of interest are neural networks, fuzzy logic, artificial intelligence, power electronics, MATLAB, FACTS, and so on. He can be contacted at email: dakkaobulesh@gmail.com.



Sairaj Arandhakar    was received the B.Tech. degree in Electrical and Electronics Engineering from the Vaagdevi College of Engineering, Warangal, Telangana, India in 2013, and the M.Tech. degree from the CVR College of Engineering, Hyderabad, Telangana in 2020. Currently, he is working as a Research Scholar with the Department of Electrical Engineering, National institute of Technology Andhra Pradesh, India. His research interests include BLDC motors, electric vehicles, and machine learning. He can be contacted at email: pf052202@student.nitandhra.ac.in.